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DATE 2 October 1964

Effect of Ultrasonic Cleaning on Corrosion Resistance of Phosphate-Coated Panels

TECHNICAL REPORT

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U.S. ARMY WEAPONS COMMAND

SPRINGFIELD ARMORY
Springfield, Mass.

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THE FOLLOWING PAGES ARE CHANGES

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13 January 1965

SUBJECT: Springfield Armory Technical Report

TO: Commanding Officer
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1. The technical reports entitled "Effect of Ultrasonic Cleaning on Corrosion Resistance of Phosphate-Coated Panels," Report Number SA-TR16-1122 by M. S. Spivak transmitted recently to your Center, contains the abstract cards for Report Number SA-TR20-2409. These cards were inadvertently assembled during the reproduction process. It is requested that the two abstract cards in each report be removed from the 20 copies received and be replaced by the inclosed cards. The abstract cards removed should be destroyed.

2. Your cooperation in this matter will be greatly appreciated.

FOR THE COMMANDER:

Incl
as

G. H. Bornheim
G. H. BORNHEIM
Assistant

REPORT: SA-TR16-1122

DATE: 2 October 1964

AMCMS CODE: 4230.25.6406.20.01

Effect of Ultrasonic Cleaning on Corrosion Resistance of Phosphate-Coated Panels

M. S. Spivak

PROJECT TITLE: Evaluation of Cleaning Methods and Procedures Applicable to Small Arms

PRON: M1-3-23001-01-M1-M6

Preparing Agency: Springfield Armory, Springfield, Mass.

REPORT
SA-TR16-1122

ABSTRACT

Zinc and manganese phosphated steel panels were exposed to high frequency vibrations (ultrasonic cleaning) in various media to determine the effect of this cleaning procedure on the corrosion resistance of the coated panels. Phosphated panels showed diminished corrosion resistance after exposure to these vibrations in water and water-based cleaners, but were not affected after exposure to ultrasonics when trichloroethylene was used as the medium. Phosphate-coated panels ultrasonically cleaned and then treated with supplementary oil (MIL-L-644) exhibited relatively the same corrosion resistance as oiled phosphated panels not exposed to ultrasonic vibrations. Test procedure is given and results are discussed.

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OBJECTIVE

To study the effect of ultrasonic cleaning on the corrosion resistance of phosphate-coated panels.

CONCLUSIONS

1. A water dip of phosphated panels, followed by immediate drying, does not destroy the chromic acid seal or reduce the corrosion resistance of the panels.

2. Ultrasonic cleaning of zinc and manganese-phosphated surfaces in water or water-based cleaners produces areas on the surface where corrosion resistance is reduced.

3. Ultrasonic cleaning of zinc or manganese-phosphated pieces in trichloroethylene does not alter the corrosion resistance of the coated panel.

4. Zinc or manganese-phosphated panels treated with supplementary preservative oil, MIL-L-644, subsequent to ultrasonic cleaning in water or water-based cleaners have the same resistance to corrosion as oiled panels not exposed to ultrasonic cleaning in these media.

5. The exposure time in excess of one minute has little effect on the quantity of corrosion produced on phosphated panels.

RECOMMENDATION

Ultrasonic cleaning of phosphated components and assemblies should be recognized as an acceptable process.

1. INTRODUCTION

Ultrasonic cleaning is the use of high-frequency mechanical vibrations, usually in liquids, for the purpose of removing foreign matter (dirt) from solid pieces. The process has been used successfully by industry to remove lapping compounds, oils, and greases from a variety of components.

Ultrasonic cleaning is currently being used to clean M14 rifle components, prior to packaging at the Springfield Armory. Most of these components have been phosphate-coated to provide a black nonreflective surface and to protect the part from corrosion. The effect of this ultrasonic cleaning on phosphate coatings, while known to be less harmful than the hand-scrubbing method previously employed, was not known and no information could be found in the literature.

An investigation was initiated to study the effect of these high-frequency vibrations (27 KC) on phosphate coatings, both zinc and manganese, in various types of cleaning solutions used at the Springfield Armory and/or by contractors. The results of this investigation are outlined in this report.

2. PROCEDURE

a. Preparation of Test Specimens.

Except where indicated in this report, panels of 1020 type steel, 1/32" x 2" x 4", were degreased, grit-blasted, zinc or manganese phosphated, and given a standard chromic acid dip.

b. Effect of Water on Chromic Acid Sealed Panels.

(1) Fifteen steel panels (1 - 15) were manganese-phosphated as stated in paragraph a, above. Ten additional panels (16 - 25) were manganese-phosphated similarly except that the chromic acid seal was omitted (Table I). These panels were then subjected to the salt spray test.

PROCEDURE - Continued

TABLE I

Treatment of Phosphated Panels

Panels	Post Phosphate Treatment
1 - 5 *	Used as standards for salt spray
6 - 10 *	Dipped 5 minutes in distilled water, dried, and exposed to salt-spray test
11 - 15 *	Placed in ultrasonics and distilled water for 5 minutes, dried, and exposed to salt spray test
16 - 20 **	Used as standards for salt-spray test
21 - 25 **	Placed in ultrasonics and distilled water for 5 minutes, dried, and exposed to salt spray test

* With chromic acid dip
** Without chromic acid dip

(2) The purpose of these preliminary experiments was to determine whether the coating is damaged by a water dip only or by the ultrasonic action.

c. Determination of Optimum Exposure Time to Ultrasonics.

Phosphated panels were exposed to ultrasonics in water for periods from 1 to 5 minutes each to determine the minimum exposure time to obtain corrosion. All panels were placed in a salt-spray chamber for one hour and examined for the effect of ultrasonic exposure time on corrosion.

PROCEDURE - Continued

d. Effect of Ultrasonic Cleaning in Different Liquid Media.

Zinc and manganese-phosphated panels were exposed to ultrasonics in combination with water, water plus detergents, proprietary cleaning solutions, and trichloroethylene. These panels were compared with phosphated panels not exposed to ultrasonics for evidence of corrosion, after exposure to salt-spray testing. The exposed panels and standard (not exposed to ultrasonics) panels were checked every half hour, to a maximum of three hours, for evidence of corrosion while in the salt spray cabinet. All panels were rated for degree of corrosion on the basis of light, moderate, and heavy rust, and the time required to reach each stage was noted.

e. Corrosion Resistance of Phosphated Panels Coated with Supplementary Rust Preventative.

Five zinc and five manganese phosphated panels were placed in water and exposed to ultrasonics for one minute, air-dried, and coated with protective oil meeting Specification MIL-L-644. These panels plus five standard zinc and five manganese panels, also oiled, were placed in a humidity cabinet at 110°F and 100 per cent relative humidity for six weeks so that the corrosion resistance of oil-coated, ultrasonically cleaned, phosphated panels could be studied. These panels were inspected daily for evidence of corrosion, weekends excepted.

3. RESULTS AND DISCUSSION

a. Effect of Water on Chromic Acid Sealed Panels.

(1) The results of experiments conducted to determine the effect of the water dip on the corrosion resistance of chromic acid sealed phosphated panels are given in Table II.

RESULTS AND DISCUSSION - Continued

TABLE II

Effect of Water on Chromic Acid Sealed Panels

Time Panel Exposed to Salt-Spray Test (hr)	Panels	Degree of Rust: None	Very Light	Light	Moderate	Heavy	Very Heavy
1/2	1 - 5a	X					
	6-10a	X					
	11-15a,c	X					
	16-20b	X					
	21-25b,c	X					
1	1 - 5	X					
	6-10	X					
	11-15				X		
	16-20					X	
	21-25					X	
1-1/2	1 - 5			X			
	6-10			X			
	11-15				X		
	16-20					X	
	21-25						X

a. With chromic acid dip
b. Without chromic acid dip
c. Ultrasonically treated

RESULTS AND DISCUSSION - Continued

(2) Panels 1 - 5 and 6 - 10 exhibited no evidence of rust after 1 hour of exposure and light rust after 1-1/2 hours of exposure to the salt spray. Panels 11 - 15 were moderately corroded, whereas panels 16 - 20 were heavily corroded after both 1 hour and 1-1/2 hours in the salt spray. Panels 21 - 25 were heavily corroded after 1 hour and very heavily corroded after 1-1/2 hours. It was apparent that the water dip in which panels 6 - 10 were placed prior to corrosion-testing did not accelerate rust formation. The moderate rust on panels 11 - 15 indicates that the ultrasonic cleaning adversely affected the chromic acid sealed phosphate coating. The results on panels 16 - 25 show that the water dip on panels 1 - 10 did not affect or leach out the chromic acid seal from these panels, otherwise these panels would also have exhibited heavy corrosion. It was not possible to determine the effect of ultrasonics in the case of panels 21 through 25 because of the very heavy corrosion.

b. Determination of Optimum Exposure Time to Ultrasonics.

It can be seen from the test results in Table III that the time a specimen was exposed to water plus ultrasonics, in excess of one minute, had little influence on the quantity and rate of rust formation.

TABLE III

Influence of Time of Exposure to Ultrasonics on Corrosion of Phosphated Panels

Time Exposed to Ultrasonics (min)	Panels	Time Exposed to Salt Spray (hr)	Degree of Rust
1	26 - 30	1/2	None
		1	Medium
		1-1/2	Heavy
2	31 - 35	1/2	None
		1	Medium
		1-1/2	Heavy
5	36 - 40	1/2	None
		1	Medium
		1-1/2	Very Heavy

RESULTS AND DISCUSSION - Continued

c. Effect of Ultrasonic Cleaning in Different Solutions or Solvents.

Ultrasonic high-frequency vibrations adversely affected corrosion resistance when used with water and water-based detergent solutions. Corrosion appeared earlier than on the standards and was more profuse as the test progressed (Figures 1 and 2). Certain patterns were noticed (Photograph 1) on the phosphated panels after exposure to ultrasonics in the water and water-based detergents. Most of the early rust was formed in these pattern areas during corrosion testing (Photograph 2). The phosphated panels exposed to ultrasonics with trichloroethylene and the proprietory compound compared favorably corrosionwise with the standards, and these patterns were not observed. The data on these results are presented in Figures 3 and 4.

d. Corrosion Resistance of Phosphated Panels Treated with Supplementary Protective Oil.

No significant difference in corrosion resistance could be noted between ultrasonically cleaned zinc and manganese phosphated panels protected with supplementary oil (MIL-L-644) and standard zinc and manganese, not ultrasonically cleaned, but coated with the same oil. The first corrosion appeared on all panels after 35 days' exposure in the humidity cabinet. As the test continued, the progressive rust formation appeared to be equal on most panels. The experimental evidence reported above is summarized in Table IV.

RESULTS AND DISCUSSION - Continued

TABLE IV

Corrosion Resistance of Phosphated Panels
Treated with Supplementary Protective Oil

Panels	Ultra-sonically Cleaned	Type Phosphate Coating	Days Exposed to Humidity Cabinet 0	35	37	42
41-45	Yes	Zinc	A	B	C	D
46-50	No	Zinc	A	B	C	D
51-55	Yes	Manganese	A	B	C	D
56-50	No	Manganese	A	B	C	D

A - No Rust
B - Very Light Rust
C - Light Rust
D - Moderate Rust

Although there is some detectable damage resulting from the ultrasonic cleaning of phosphate coatings in aqueous media, the usual ordnance practice of application of supplementary protective oils to phosphated surfaces precludes this damage from being significant or important. It is apparent that the coating remaining after ultrasonic cleaning is sufficient to absorb the oil and to provide satisfactory corrosion resistance.

Appendix A - Figures

Appendix B - Photographs

Appendix C - Distribution

Figures

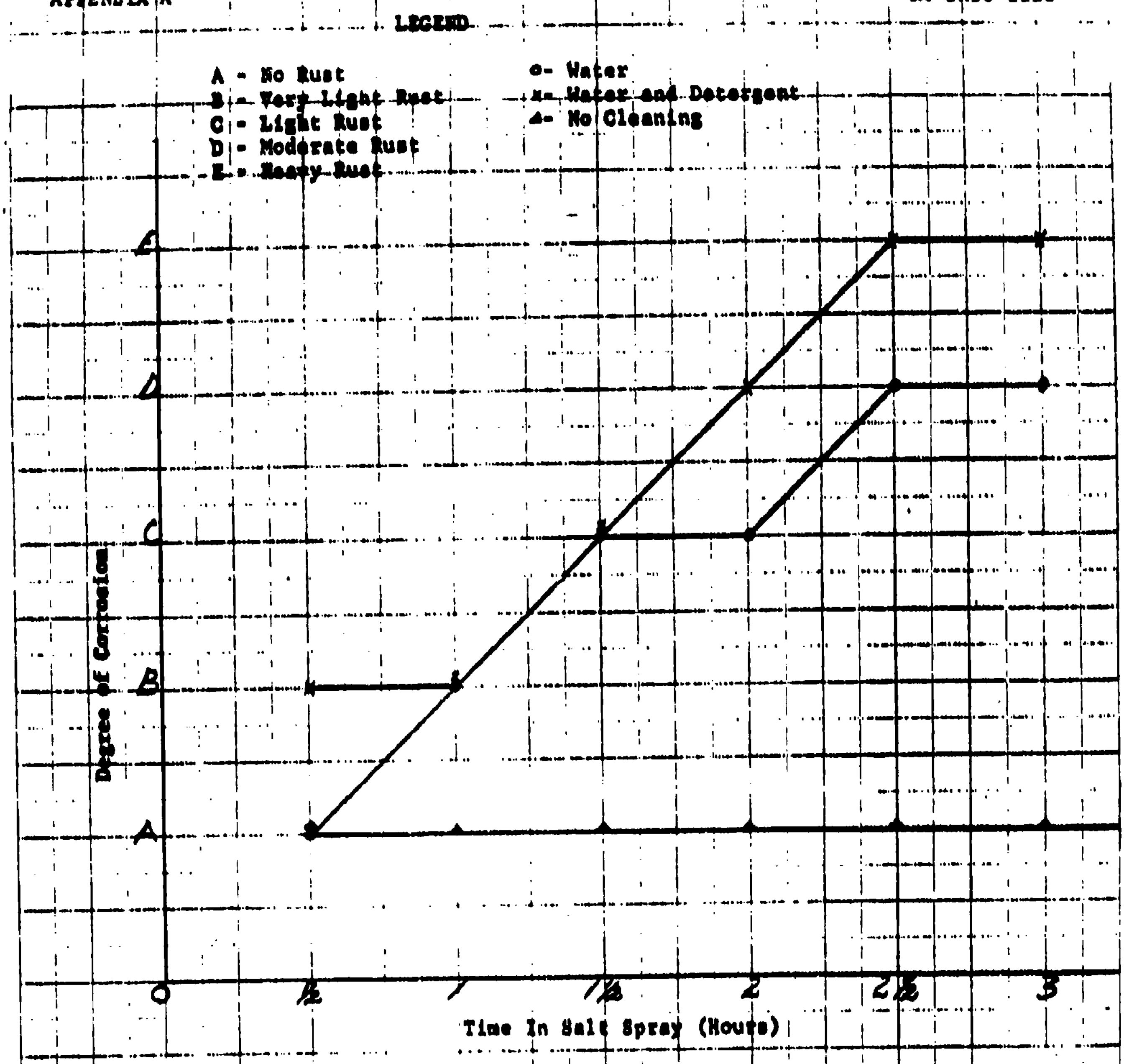


FIGURE 1. EFFECT OF ULTRASONIC CLEANING IN WATER AND WATER PLUS DETERGENTS ON ZINC PHOSPHATED PANELS

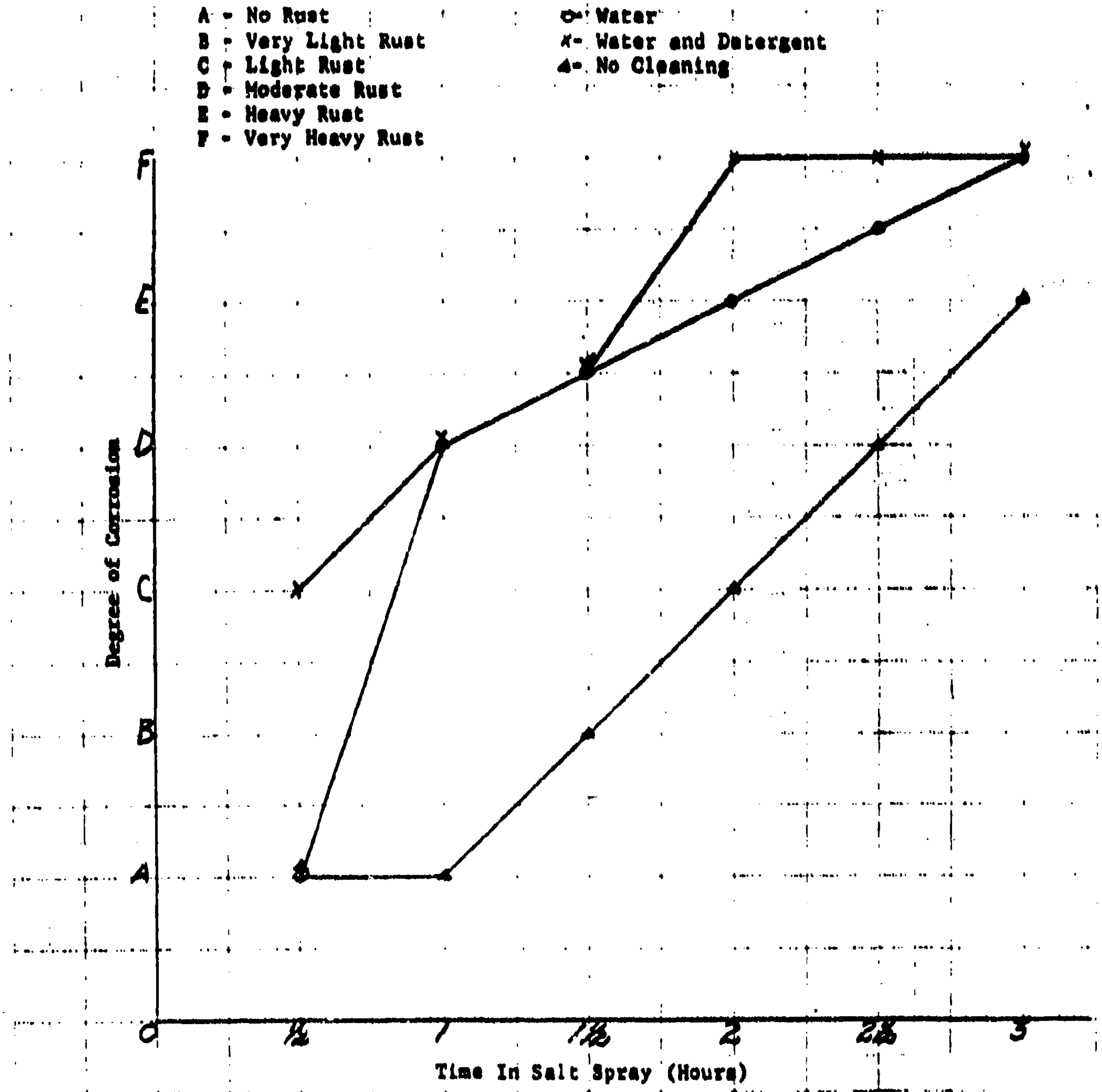


FIGURE 2. EFFECT OF ULTRASONIC CLEANING IN WATER AND WATER PLUS DETERGENTS ON MANGANESE PHOSPHATED PANELS

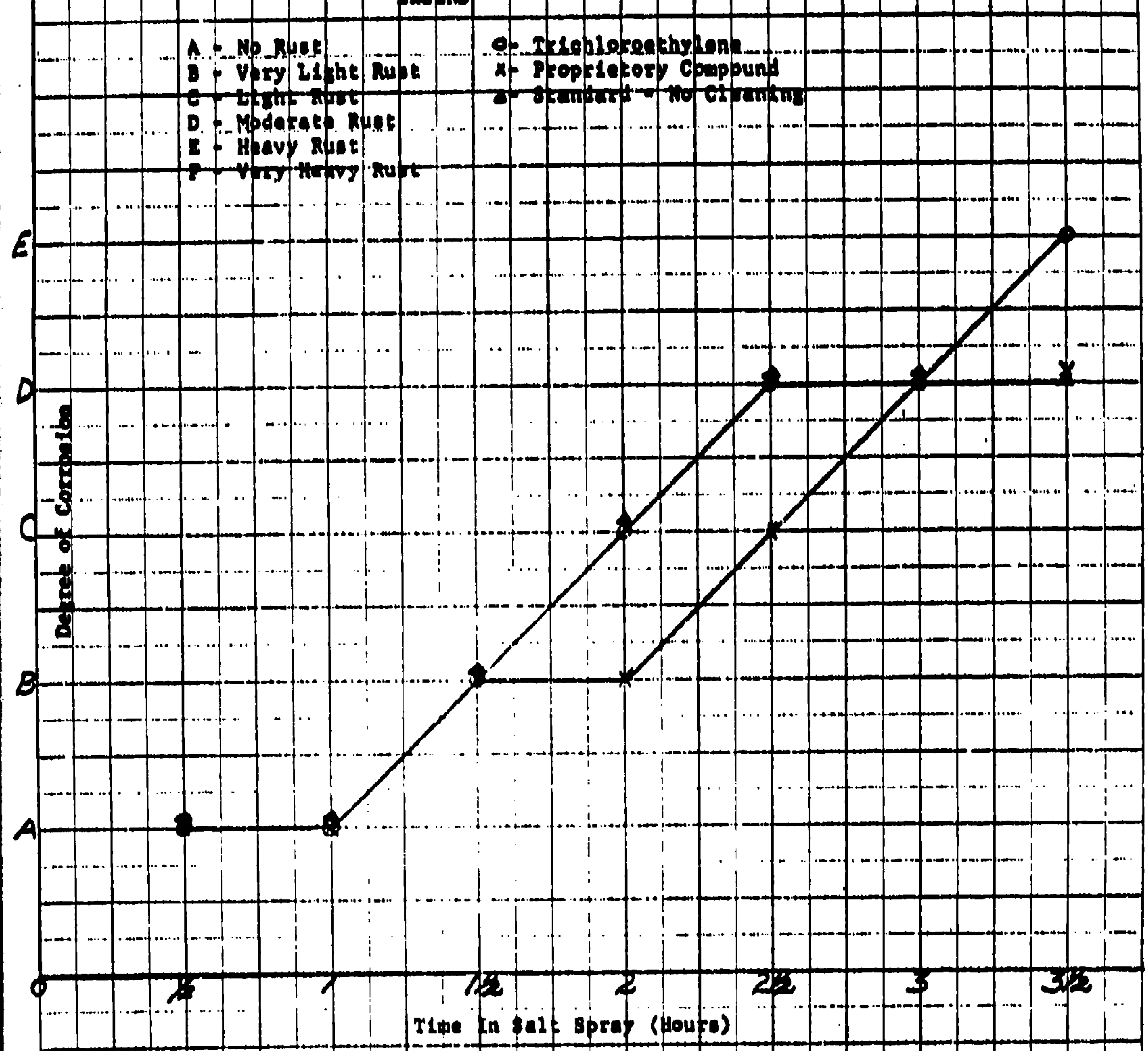


FIGURE 3. EFFECT OF ULTRASONIC CLEANING OF MANGANESE PHOSPHATED PANELS IN TRICHLOROETHYLENE AND PROPRIETARY COMPOUND

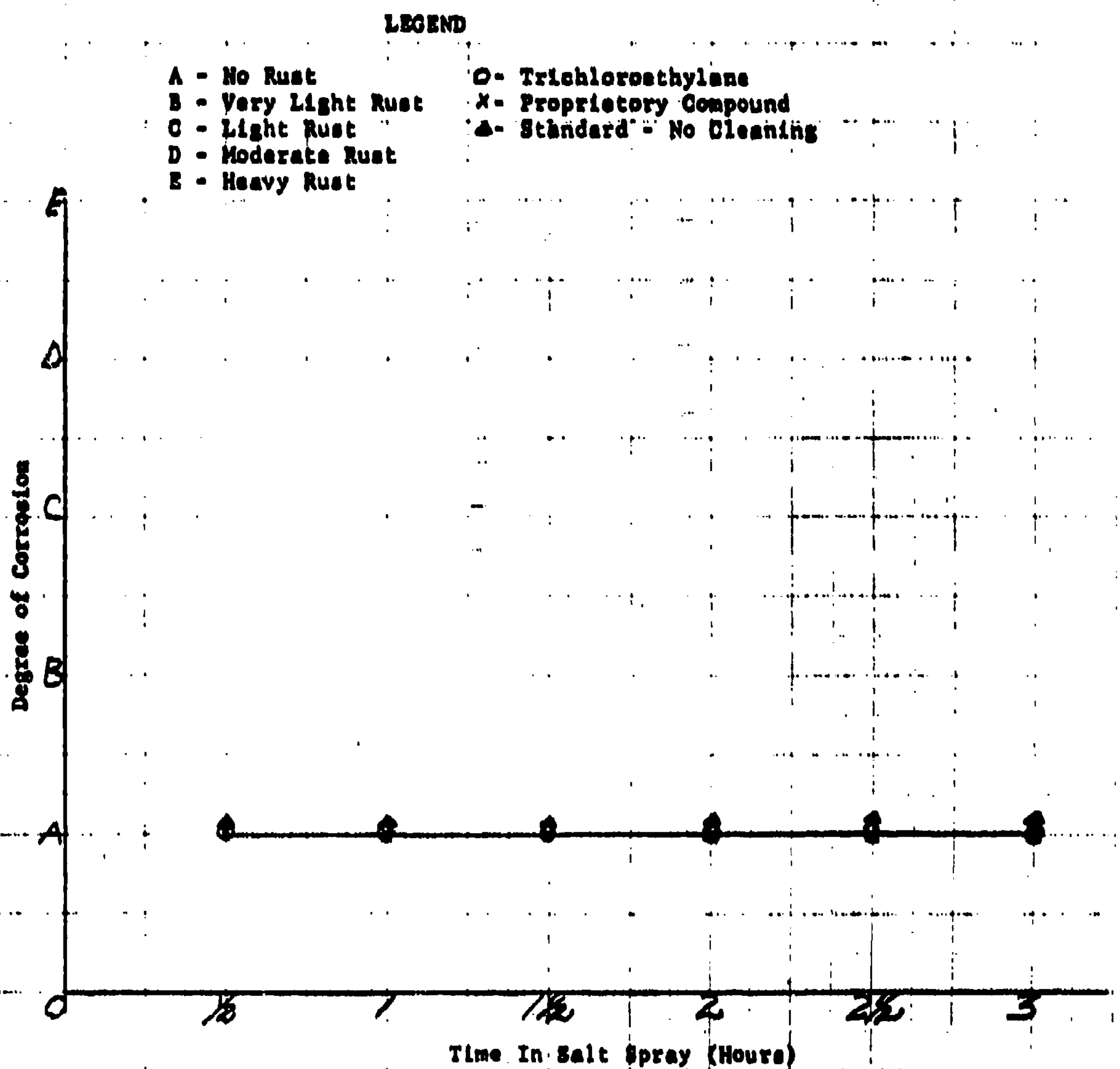
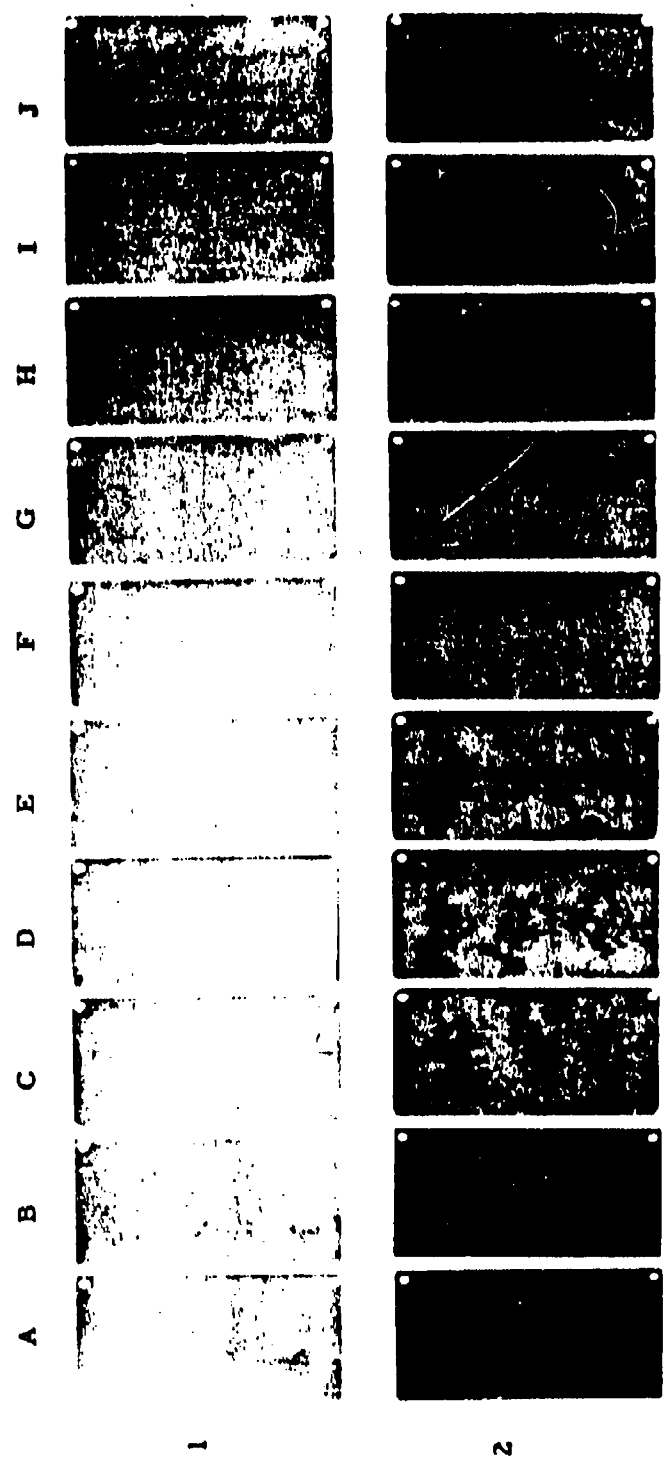


FIGURE 4. EFFECT OF ULTRASONIC CLEANING OF ZINC PHOSPHATED PANELS IN TRICHLOROETHYLENE AND PROPRIETARY COMPOUND

Photographs

No.	Title Caption
19-058-1232/AMC-64	Manganese and Zinc Phosphated Panels after Exposure to Ultrasonic Cleaning in Water as Compared with Standards
19-058-1233/AMC-64	Manganese and Zinc Phosphated Ultrasonically Cleaned and Tested for Two Hours in Salt Spray

Manganese and Zinc Phosphated Panels after Exposure to Ultrasonic Cleaning in Water as Compared with Standards

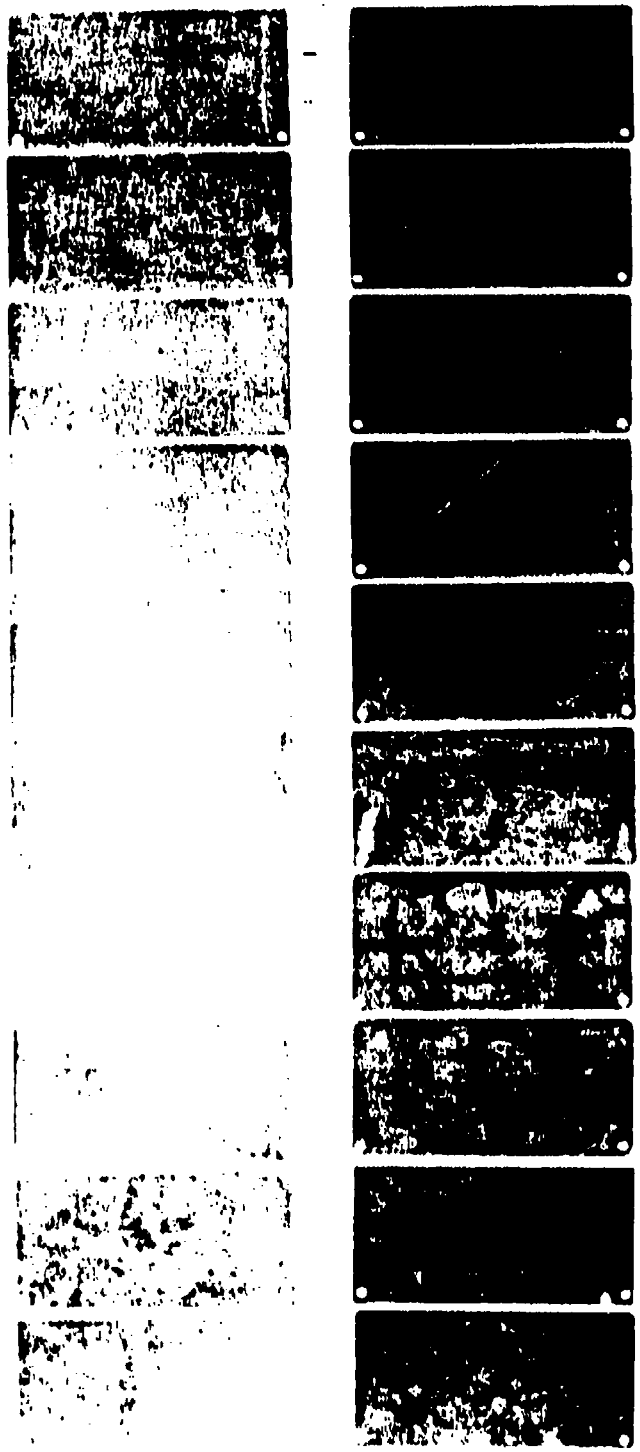


A, B, C, D, E, - Standards
F, G, H, I, J - Exposed to Ultrasonics

Legend
1 = Manganese Phosphated
2 = Zinc Phosphated

Manganese and Zinc Phosphated Ultrasonically Cleaned and Tested for Two Hours in Salt Spray

A B C D E F G H I J



1

2

Legend
1 = Manganese Phosphated
2 = Zinc